ES ELECTRONIC SYSTEMS

TU/e EINDHOVEN UNIVERSITY OF TECHNOLOGY

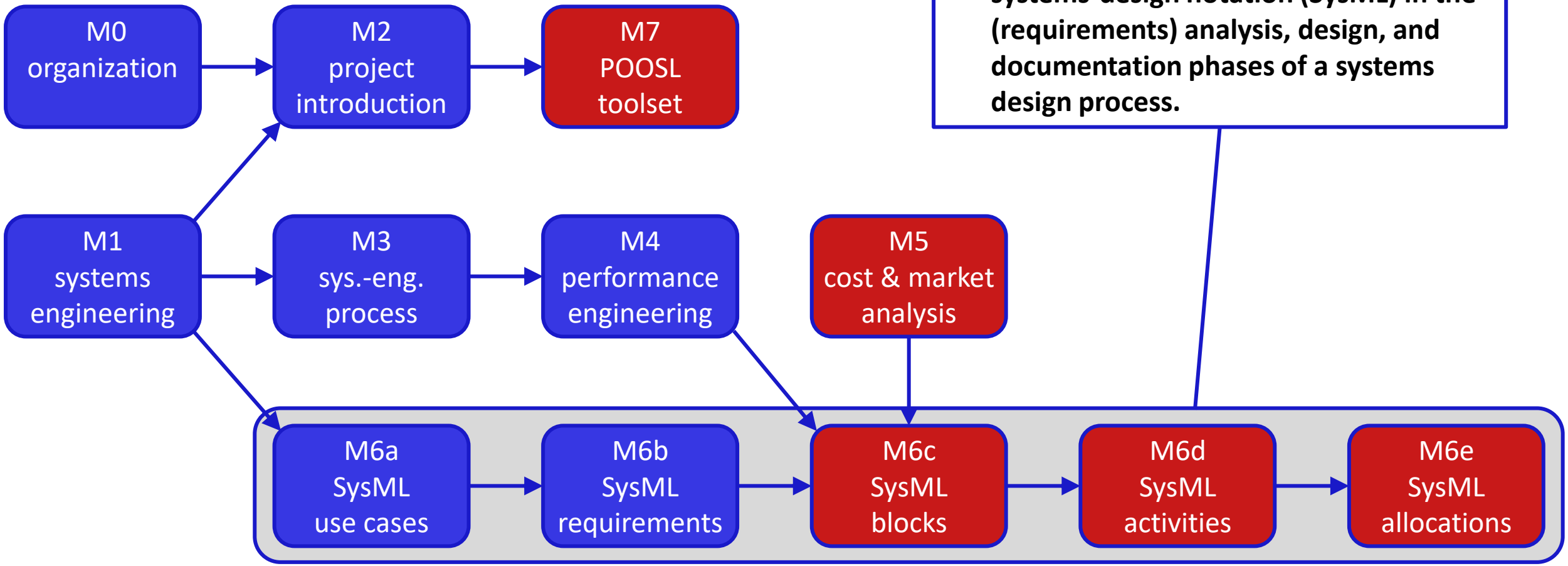
5XIC0 Electronic-Systems Engineering

Twan Basten, Martijn Hendriks

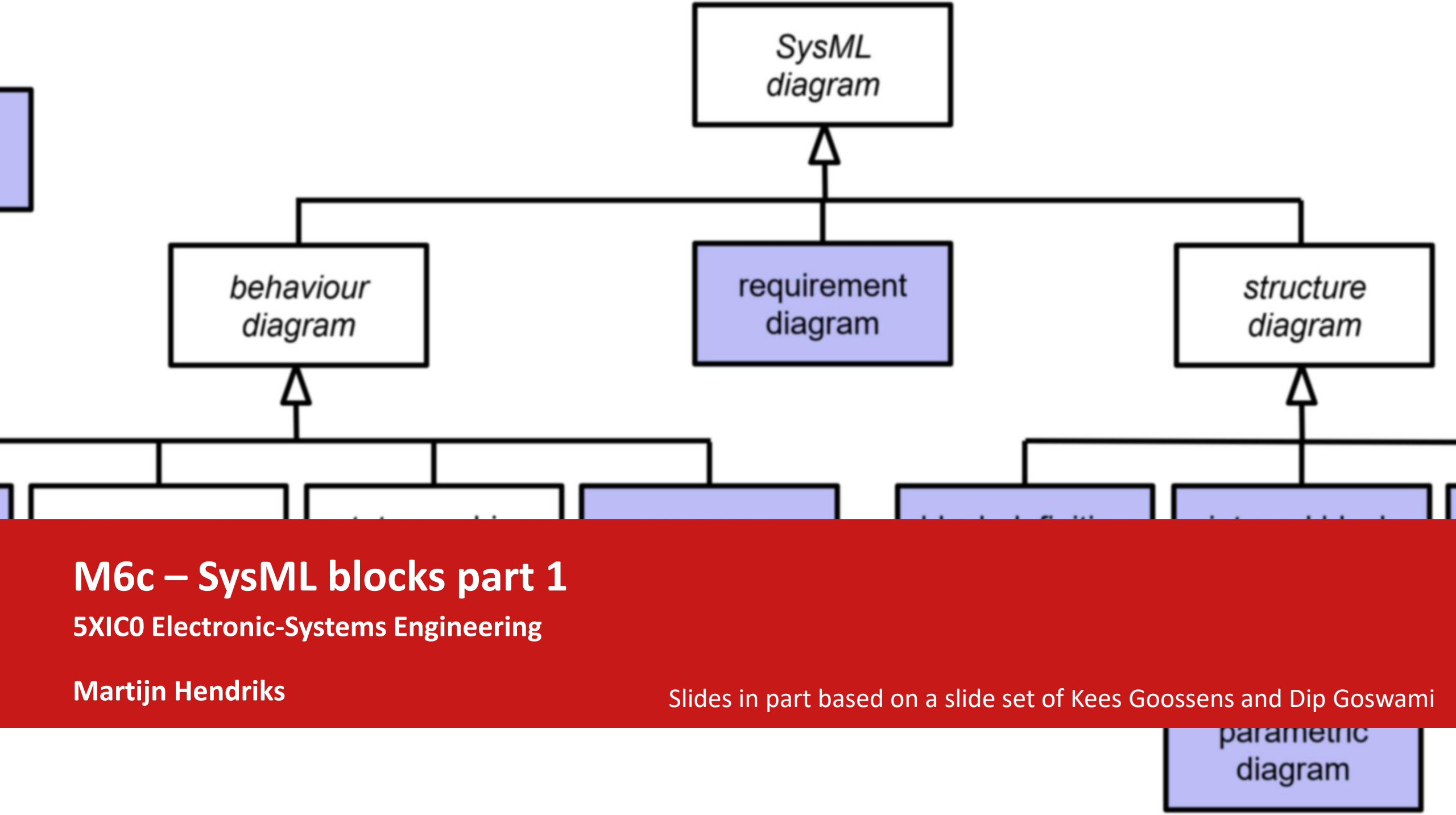
Electrical Engineering

modules

2. Know and be able to use a standard systems-design notation (SysML) in the (requirements) analysis, design, and documentation phases of a systems design process.



ES ELECTRONIC SYSTEMS TU/e



M6c – SysML blocks part 1

5XIC0 Electronic-Systems Engineering

Martijn Hendriks

Slides in part based on a slide set of Kees Goossens and Dip Goswami

in this lecture

SysML blocks

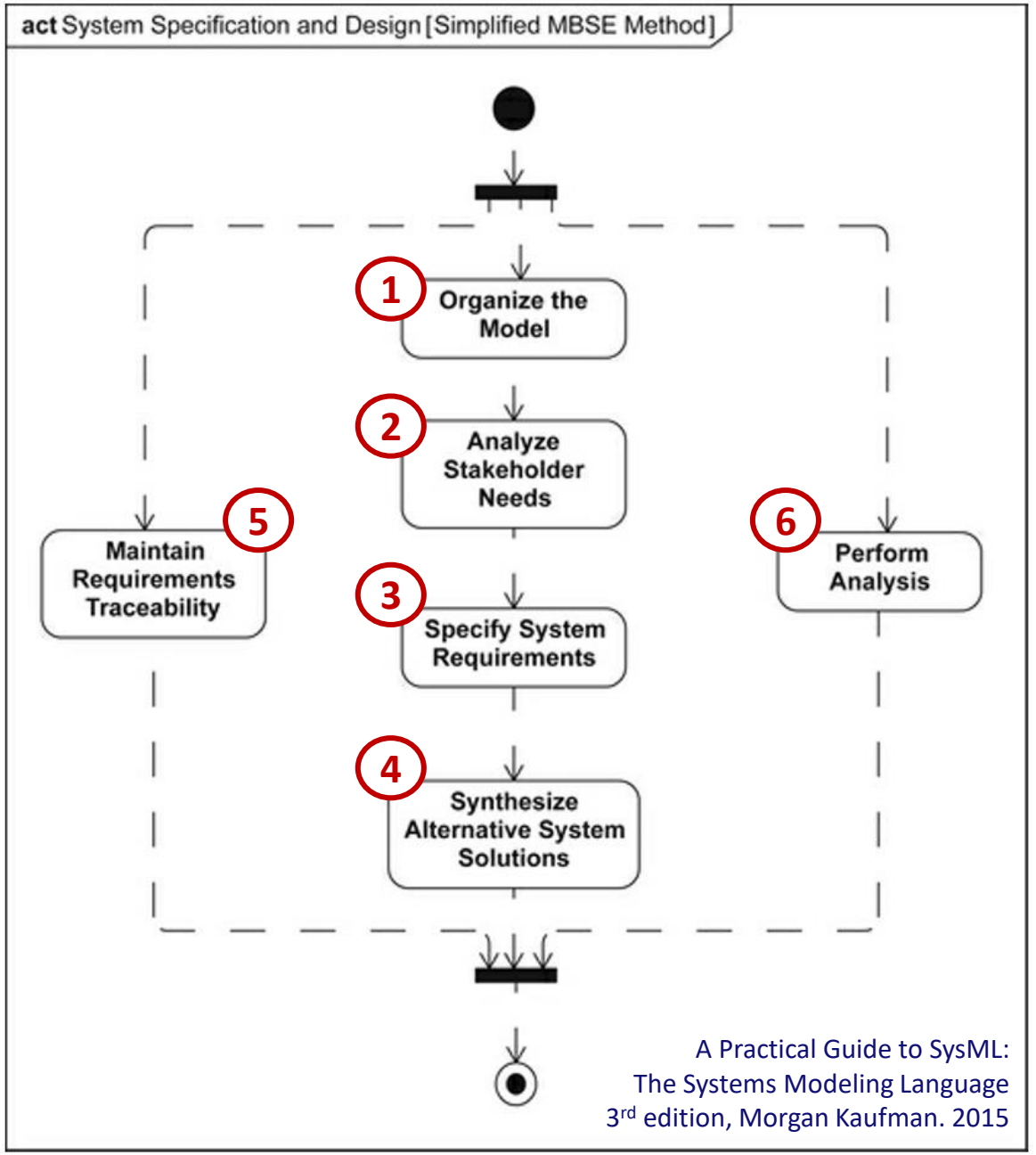
- blocks and their relations
- modeling system structure

diagrams

- block definition diagrams

a simplified^2 MBSE method

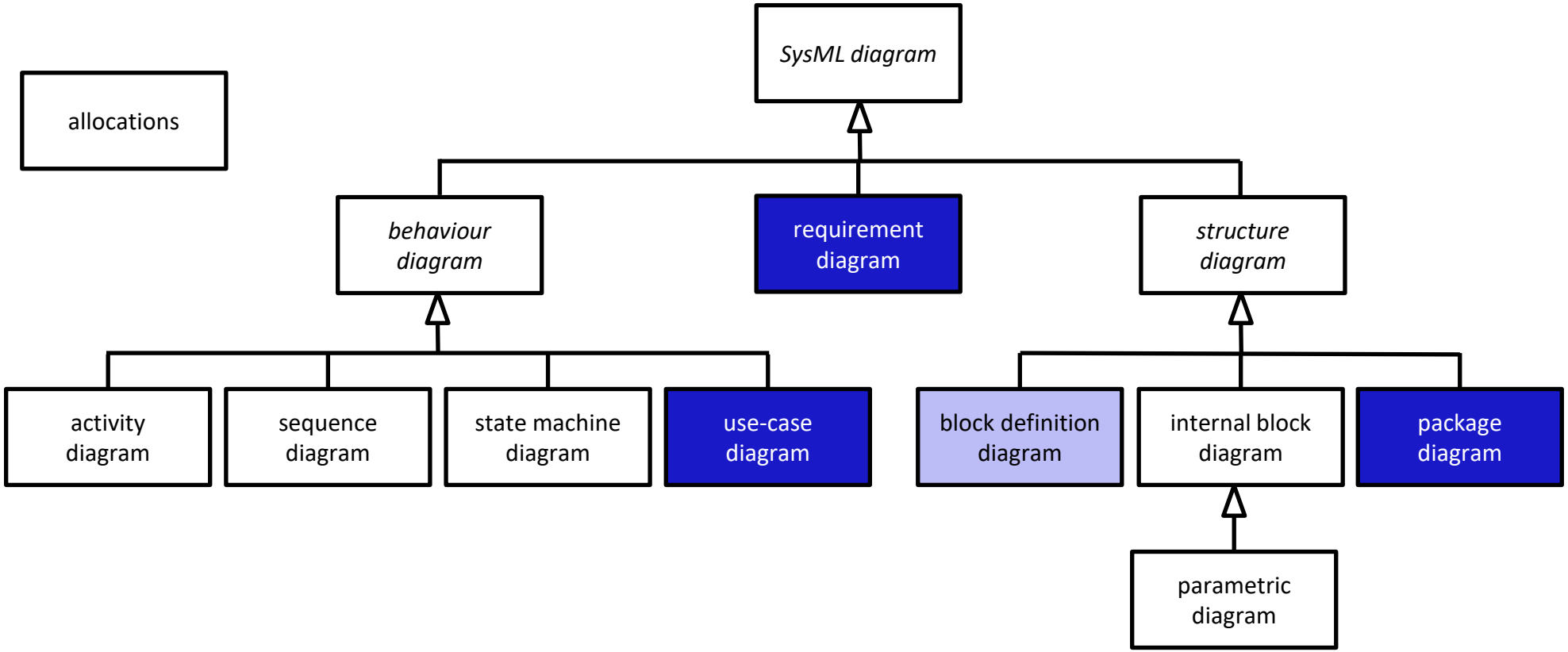
1. SysML package diagram
2. stakeholders
   SysML UC diagrams, UC descriptions
   measures of effectiveness (moes)
3. SysML requirement diagrams
4. create multiple alternatives
   - SysML BDDs – system decomposition
   - SysML IBDs – interconnections
   - SysML Activity diagrams – UC refinements
   - SysML Allocations – activities to blocks
5. requirements tracking
   - SysML Allocation – reqs to blocks/activities
6. - SysML PAR diagrams – covering all moes
   - POOSL models – makespan
   - analytical model – profit
   - verification



A Practical Guide to SysML:
The Systems Modeling Language
3rd edition, Morgan Kaufman. 2015

SysML – diagram overview

diagrams are **views** on the model
(i.e., on a subset of model elements)



SysML – blocks – what is it

a block is the modular unit of structure

- physical entity (a system, hardware, …)
- a person, facility (building, road) or entity in the natural environment (atmosphere, ocean, …)
- type of logical or conceptual entity (software, data, …)
- entity that flows through a system (water, current, data, control commands, …)

a block describes a set of instances that share the block's definition

a block has

- structural features that define its internal structure and properties
- behavioral features that define how it interacts with environment and modifies its own state

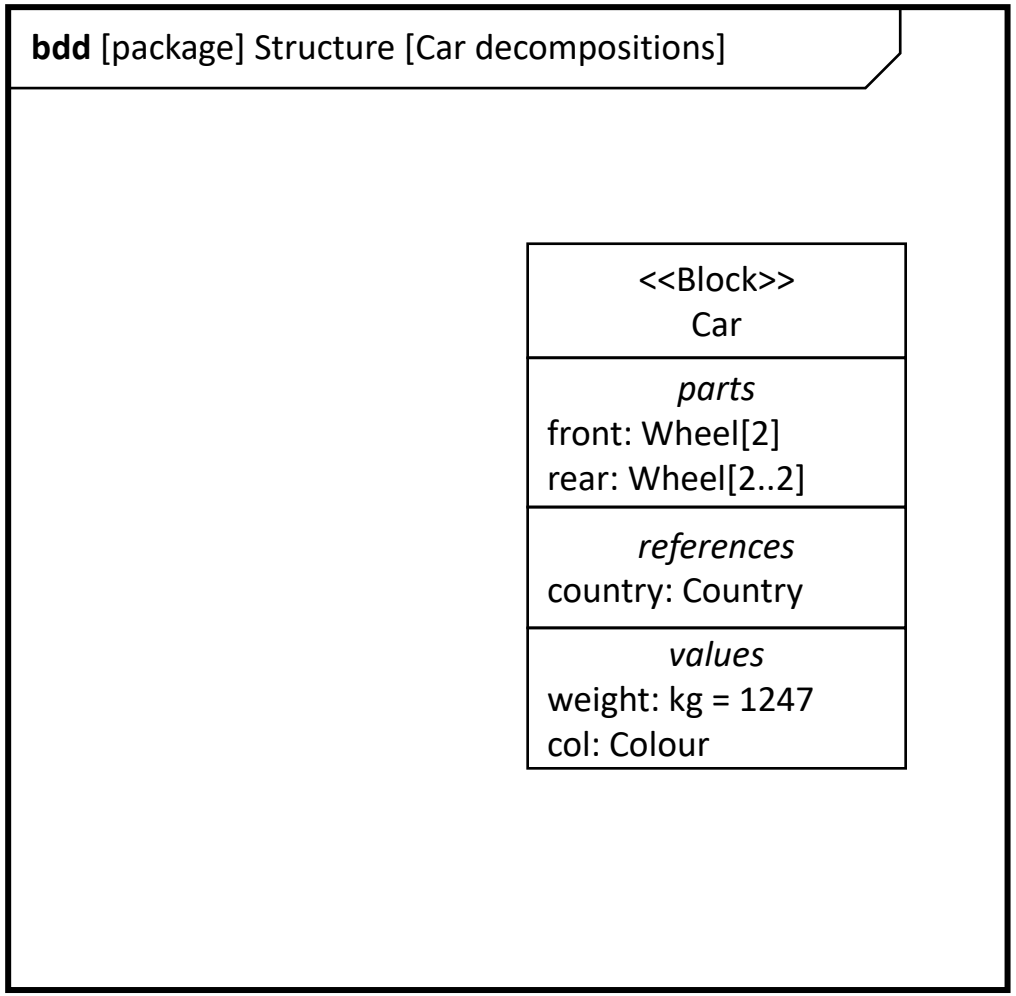
SysML – blocks – model elements

structural features (properties) of a block

- parts: composition relationship between blocks (e.g., a car has two front wheels)
- references: refer to another block instance; a "needs relationship" (e.g., a car is made in some country)
- values: quantitative characteristics of blocks (e.g., weight)
- *ports*: next lecture
- *flow properties:* next lecture

structural features

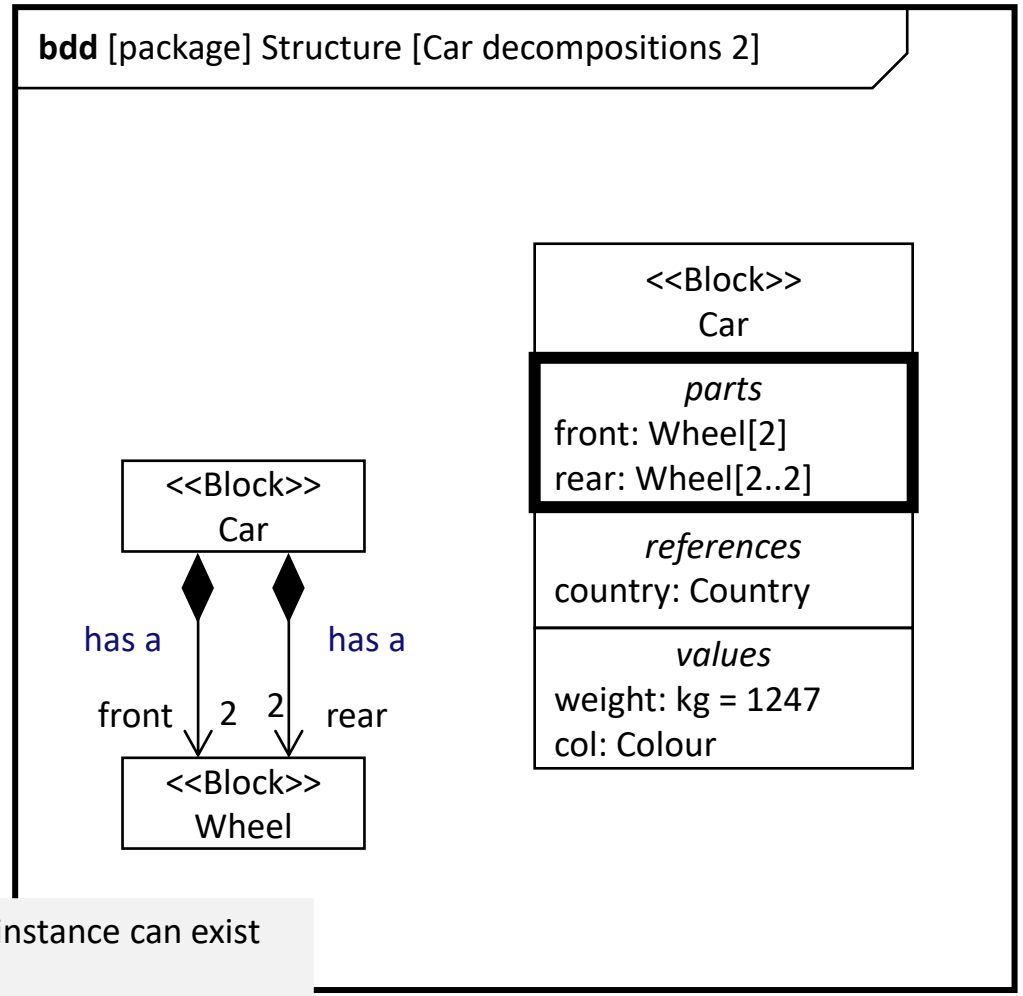
- have multiplicities, i.e. a lower and upper bound, e.g., 1, 0..1, 1..*, …
- can be shown in block compartments



SysML – blocks – model elements – relations

composite association: relates two blocks in whole-part relationship

- line between two blocks with a diamond (whole) and open arrowhead (part); name is optional
- implies a part property in the owning block
- multiplicities:
  - owner: [0..1] (default), or 1
  - part: anything, e.g., 1 (default), 0..1, 1..3, *, …



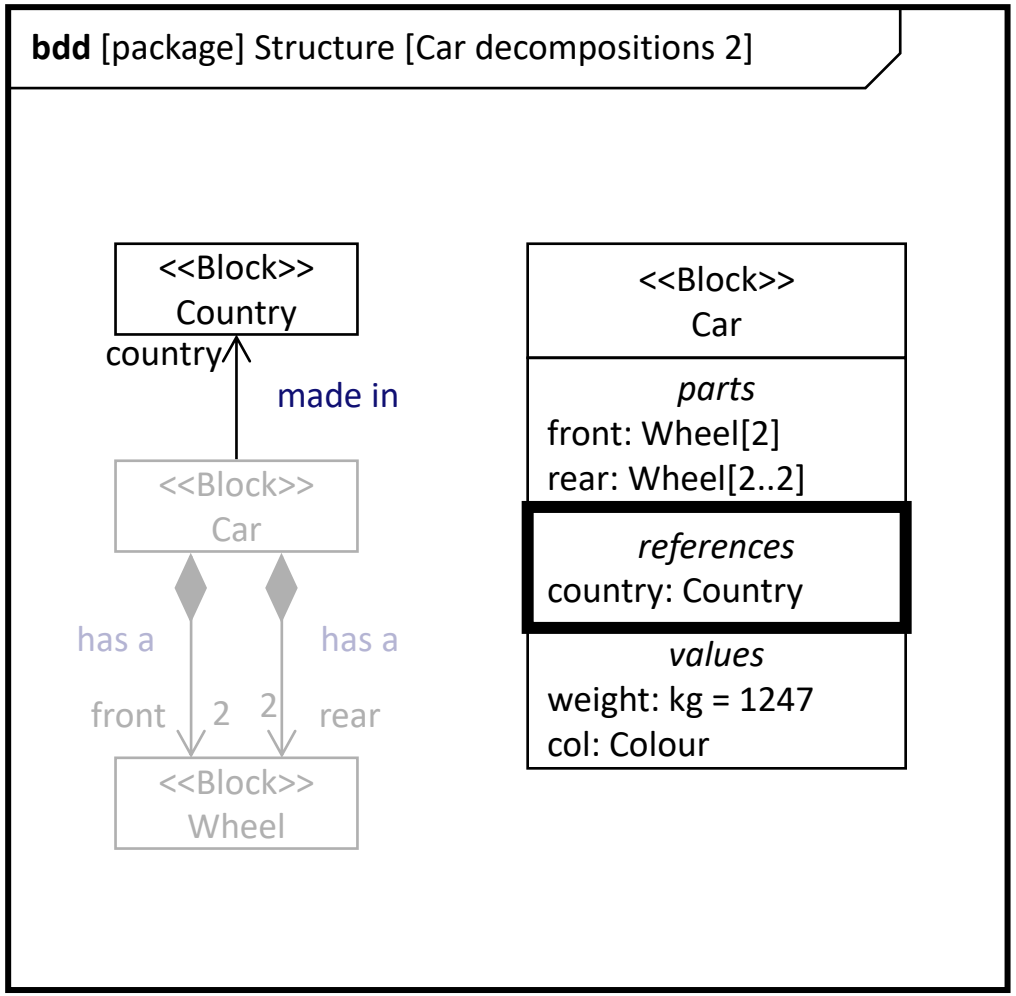
[0,1] multiplicity on whole end: part instance can exist even if it is not part of a whole

[1] multiplicity on whole end: part instance cannot exist without being part of a whole

SysML – blocks – model elements – relations

reference association: represents a "needs" relationship, not ownership

- line between blocks with an open arrowhead (unidirectional), or no arrowhead (bidirectional)
- implies a reference property in the blocks(s)
- multiplicities free (default is 1)

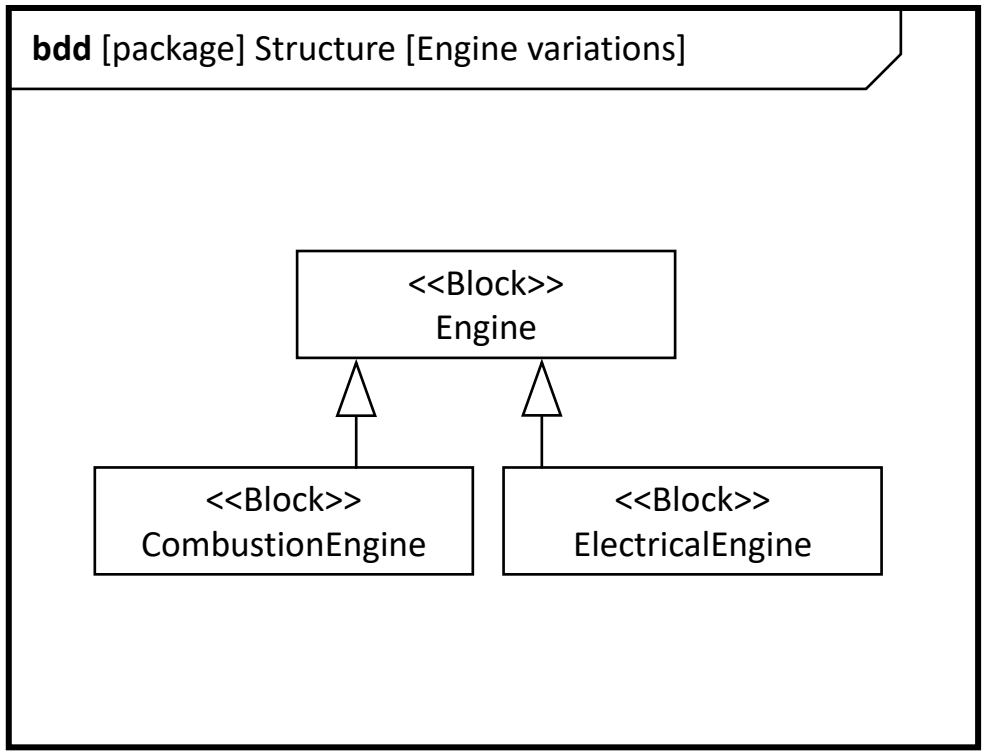


SysML – blocks – model elements – generalization

specialization/generalization: relates blocks in a classification hierarchy

- a classifier is a type (a block) that may be used as the basis for more specific types
- a general classifier contains features that are common to more specialized classifiers
- a more specified classifier (subclass/subtype) inherits the features of the more general classifier (superclass/supertype)

line between two blocks with a hollow arrowhead (more general type): *no multiplicities*



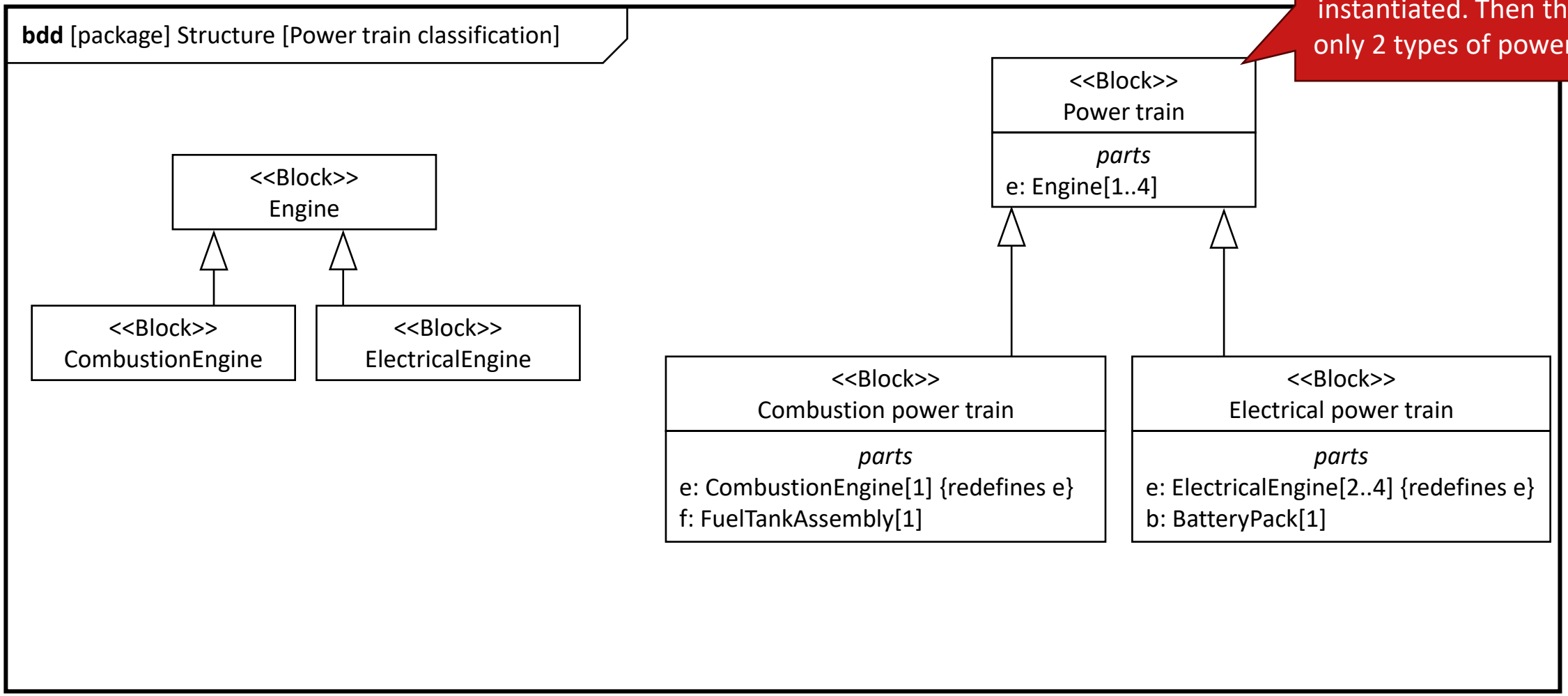
SysML – blocks – model elements – generalization

specialization adds features

specialization can redefine features

- restrict multiplicity
- restrict the type of the feature
- add or change a default value

SysML – block definition diagram (bdd)



SysML – blocks – recommended reading

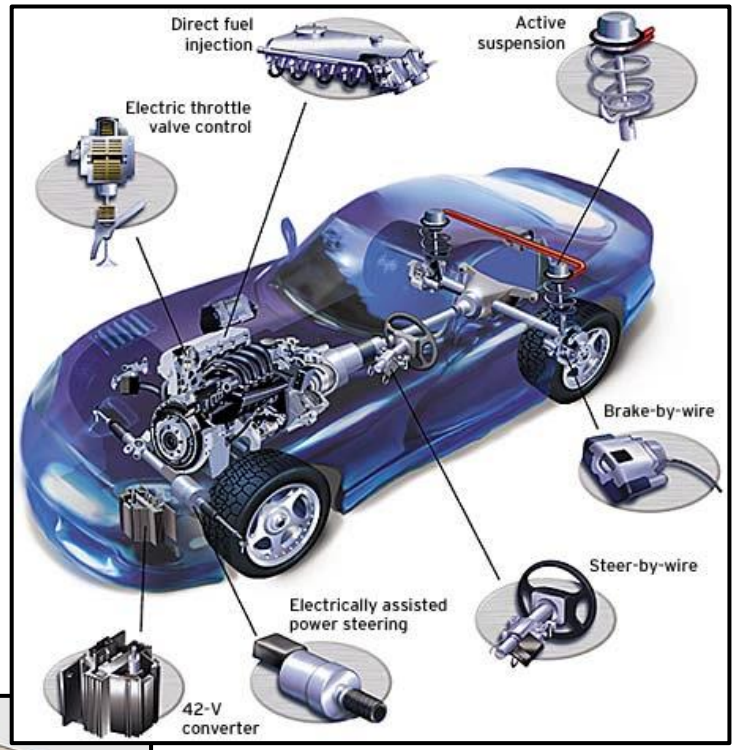
sections 7.2, 7.3 (not about internal block diagrams), 7.7 intro, 7.7.1

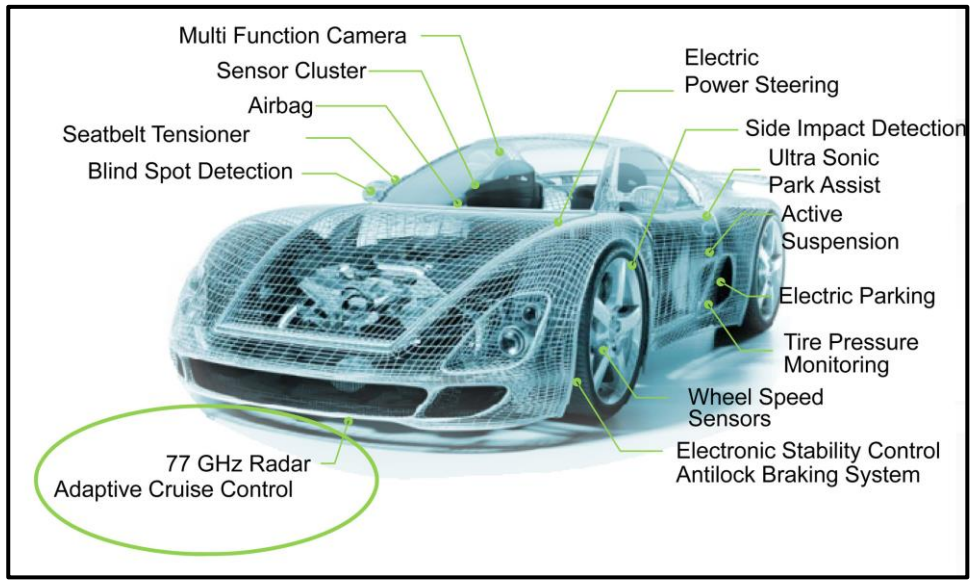
quiz

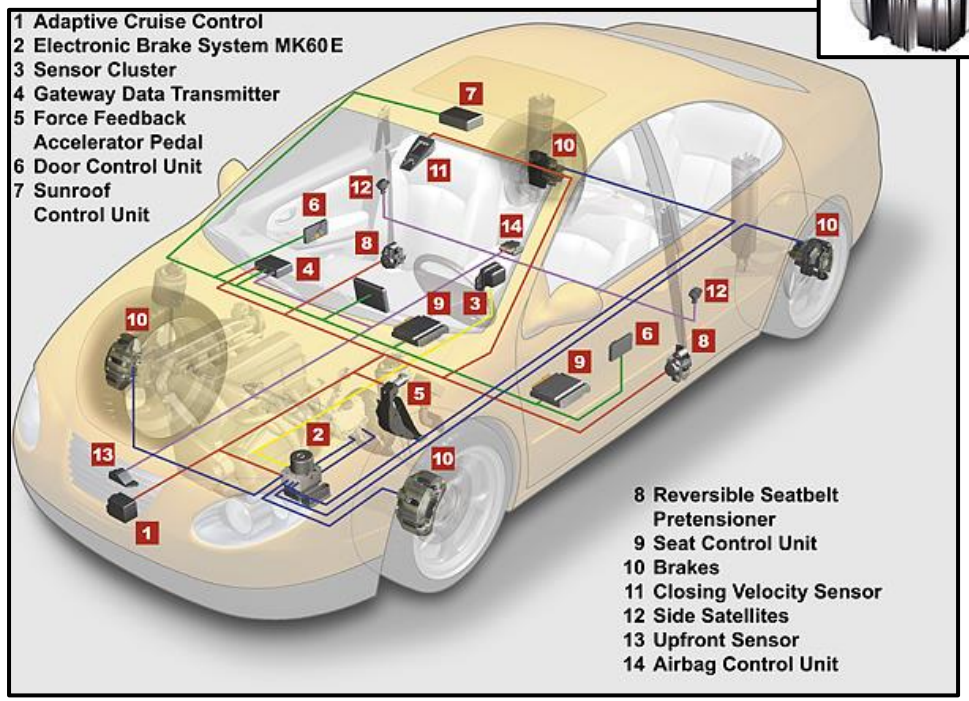
- name a few model elements that can be used for BDDs
  - blocks, with structural properties (parts, references, values, ports, flow properties)
  - composite association between blocks
  - reference association between blocks
  - specialization/generalization between blocks (creates a classification hierarchy)

SysML – running example

A vehicle has a power train as one of its components. This power train can have a combustion engine, hybrid engine, or be fully electric. A hybrid power train has a single electric engine, and a fully electric one can have two or four (electric) engines. A combustion engine needs a fuel tank, and cars with an electric engine need a battery pack. Finally, we have 4 and 6-cylinder combustion engines.







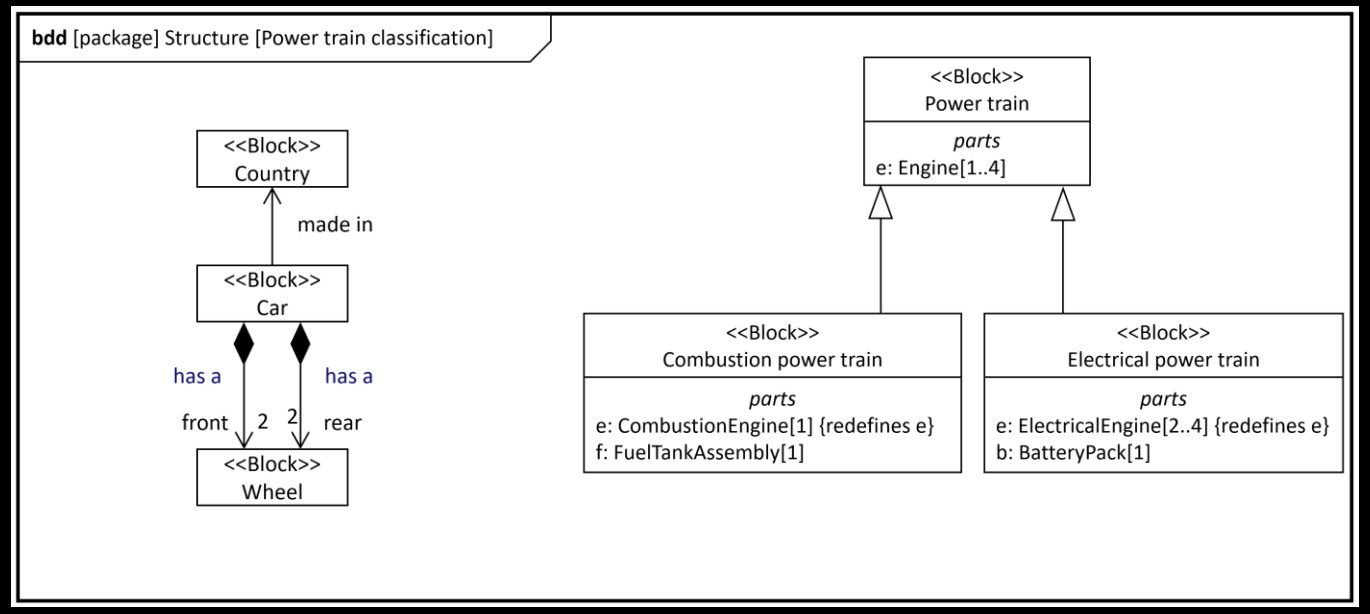
sources: motorola, aa1car.com

ES ELECTRONIC SYSTEMS TU/e

think – pair – share

create one or more BDDs for the following description

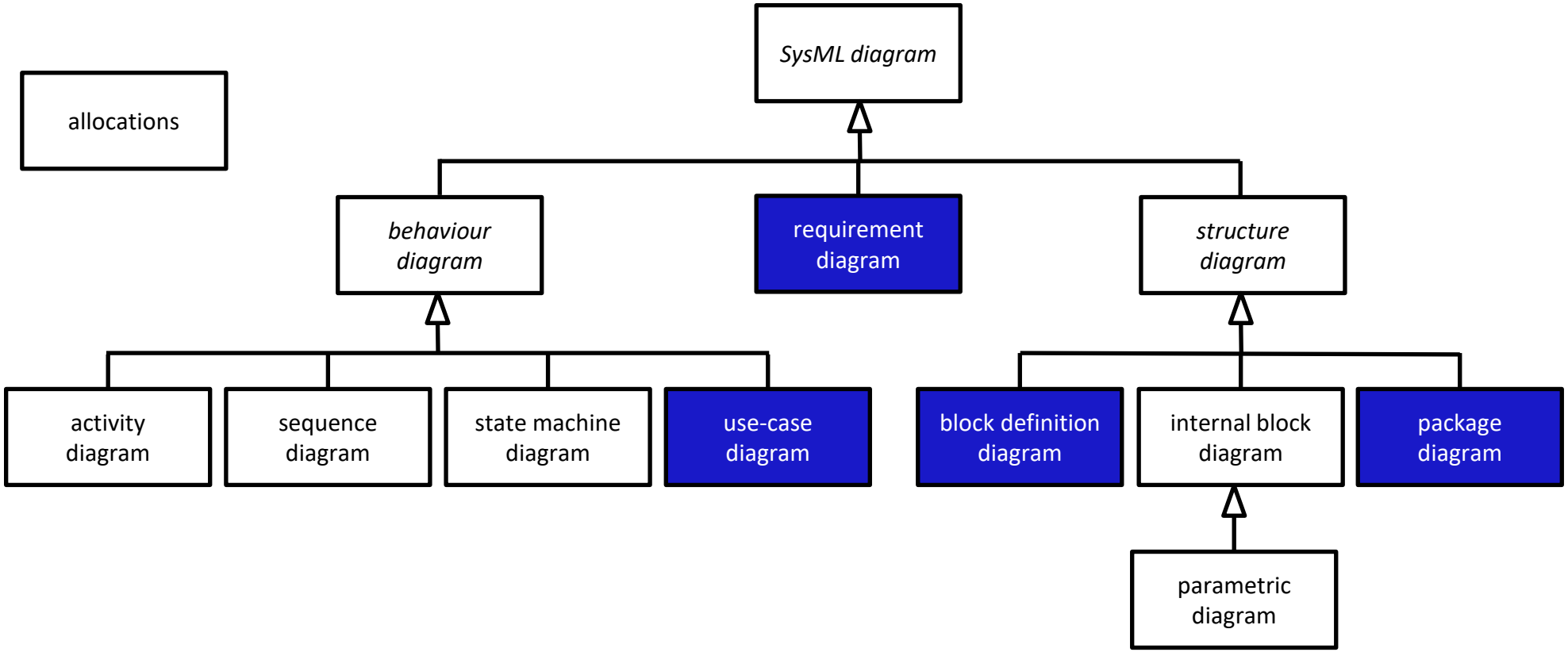
A vehicle has a power train as one of its components. This power train can have a combustion engine, hybrid engine, or be fully electric. A hybrid power train has a single electric engine, and a fully electric one can have two or four (electric) engines. A combustion engine needs a fuel tank, and cars with an electric engine need a battery pack. Finally, we have 4 and 6-cylinder combustion engines.



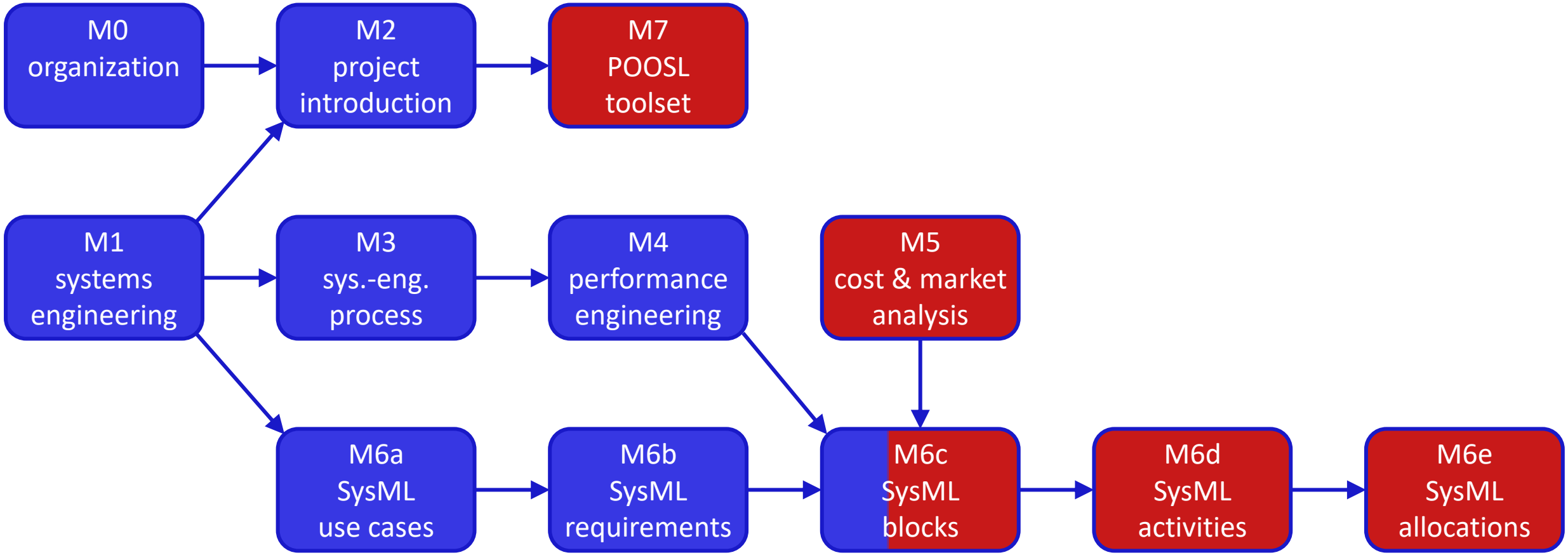
inspiration

SysML – diagram overview

diagrams are **views** on the model
(i.e., on a subset of model elements)



modules


M0
organization
M2
project
introduction
M7
POOSL
toolset
M1
systems
engineering
M3
sys.-eng.
process
M4
performance
engineering
M5
cost & market
analysis
M6a
SysML
use cases
M6b
SysML
requirements
M6c
SysML
blocks
M6d
SysML
activities
M6e
SysML
allocations

to remember

blocks can be used to model the *structure* of a system

composite association models “part of” relationship

reference association models “needs” relationship; it can cut through the part-of tree

generalization relates blocks in a classification hierarchy

specialization adds and/or redefines features

multiple bdd’s for multiple viewpoints (e.g., composition tree vs classification tree)